Application of Ion Mobility Spectrometry (IMS) in Forensic Chemistry and Toxicology with focus on biological matrices

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ABSTRACT

The IMS instrument "Ionscan" takes advantage of the fact that trace quantities of illicit drugs are adsorbed on dust particles on clothes, in cars and on other items of evidence. The dust particles are collected on a membrane filter by a special attachment on a vacuum cleaner. The sample is then directly inserted into the spectrometer and can be analyzed immediately. We show casework applications of a forensic chemistry and toxicology laboratory. One new application of IMS in forensic chemistry is the detection of psilocybin in dried mushrooms without any further sample preparation.

KEY WORDS: Ion mobility spectrometry, forensic chemistry, forensic toxicology, illicit drugs, psilocybin, instrumental thin layer chromatography

INTRODUCTION

At the Department of Forensic Chemistry and Toxicology at the Institute of Forensic Medicine at the University of Berne two ion mobility spectrometers (Ionscan, Model 250 and 350, Barringer, Toronto, Canada) are used to help law enforcement and government agencies of several Swiss cantons to combat drug-related crimes. In the department IMS is used for the analysis of illicit street drug samples obtained by the police. Analysis is performed of evidentiary items like clothing, cars, apartments, balances, knives, pipes, etc. If these items had got contact with illegal or controlled substances the objects give off tiny particles that cling to their surface. These particles are collected onto a Teflon membrane filter by vacuuming the objects or by swabbing them with a dry cotton swab. The filter is then directly inserted into the Ionscan. The results are obtained immediately [1, 2]. Also in some cases IMS is used to obtain rapid preliminary results in forensic toxicology as well as in forensic investigations.

Applications of IMS in forensic casework

Illicit substances, including all of the most commonly used drugs (e.g. heroine, cocaine, amphetamines, MDMA, MDEA, LSD, etc.) are detected on clothes, money, in vehicles, apartments as well as on various items used to portionate drugs (e.g. balances and knives). Packages sent to prisoners are also examined by IMS. In those special cases a main advantage of IMS is, that the outside of an unopened package can easily be screened. If a negative result is obtained, the probability that the package contains illicit or controlled substances is very small. To confirm trace analysis with IMS for court cases we use electron impact GC/MS. For illicit heroine and cocaine samples, positive results with IMS are always confirmed by a

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second independent method, mostly instrumental TLC. The chromatograms are run in the system cyclohexane/toluene/diethylamine 85:5:10. Differentiation between the free base and the hydrochloride is done by FT/IR-spectroscopy. Illicit heroine samples are compared either by GC/FID, GC/PND or GC/MSD. The comparison of cocaine samples is performed by GC/MS after derivatization [3].

In one case the police seized a package of Psilocybe mushrooms. We were asked to examine the mushrooms for illicit or controlled substances. Examination of the mushrooms by IMS showed that they were contaminated with cocaine. In addition, without any sample preparation we were also able to detect psilocybin. Small amounts of ground mushrooms were put onto the membrane filter and directly inserted into the Ionscan. Blank dried mushrooms bought from a food store were used as a negative control. Figure 1 shows the plasmagram of this negative control. Figure 2 shows the plasmagram of the seized Psilocybe mushrooms.

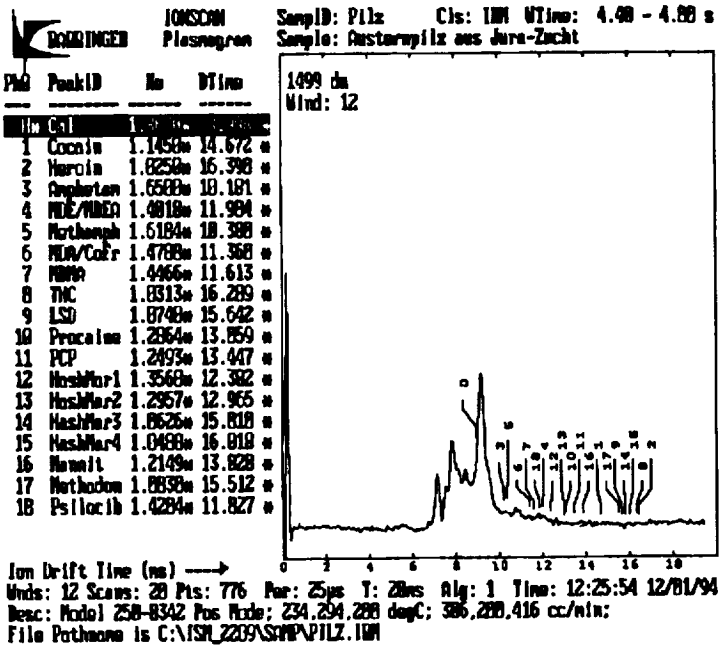

Fig. 1: Plasmagram of negative control

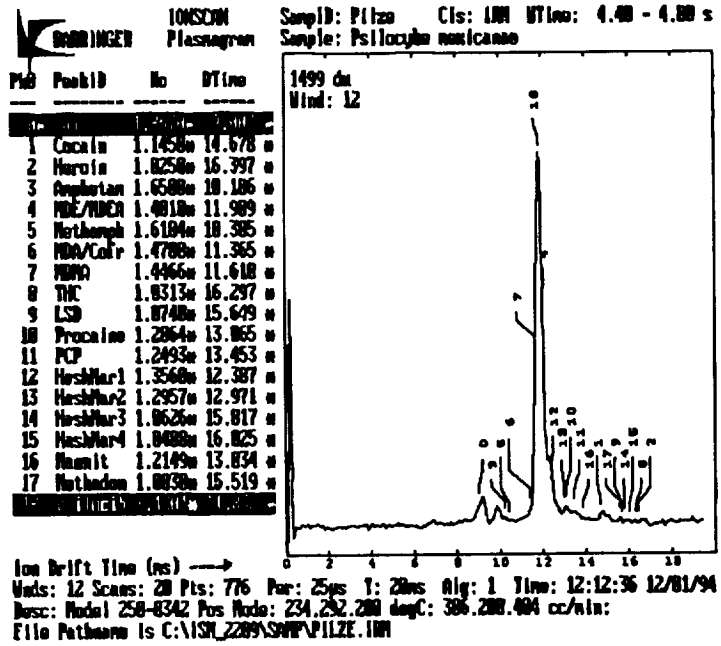

Fig. 2: Plasmagram of Psilocybe mushrooms

To verify that the observed signal at DTime = 11.83 ms stands for psilocybin a psilocin and psilocybin standard solution was also examined. Figure 3 and Figure 4 show the plasmagrams of the corresponding standard solutions.

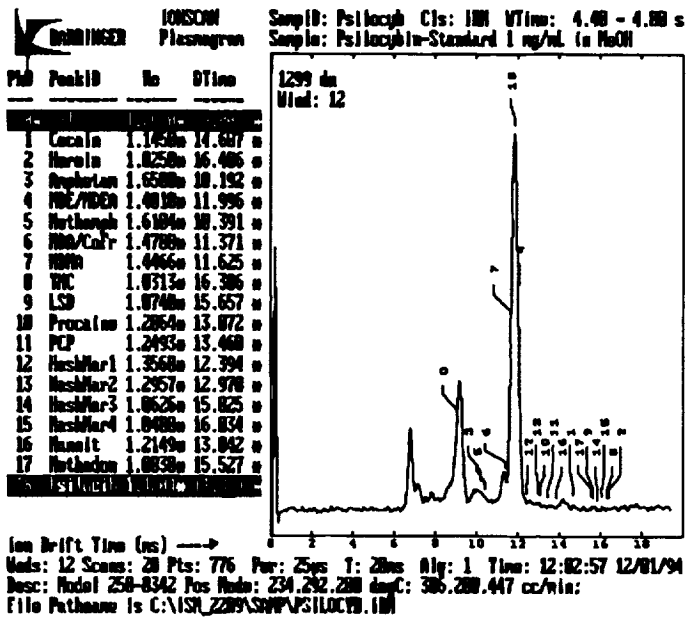

Fig. 3: Plasmagram of the psilocybin standard solution

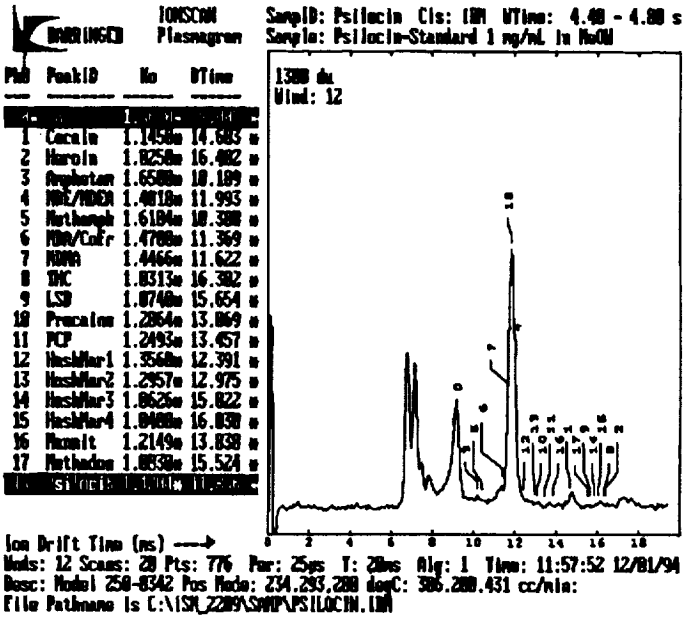

Fig. 4: Plasmagram of the psilocin standard solution

Comparison of Figure 3 and 4 shows that the plasmagrams of both standard solutions give the same drift time for the two substances. The appearance of a signal at DTime = 11.83 ms indicates that in the IMS ion source psilocybin is converted into psilocin.

Confirmation of the presence of both psychotropic substances was done by TLC.
A 1 mg/mL psilocin and psilocybin standard solution were used as reference. The ground mushrooms were extracted with methanol. The organic layer was separated from the residue through a filter and the clear solution was completely evaporated. The residue was then redissolved in 100 µL methanol. TLC was performed on a silica plate in the system methanol/acetic acid/water 75:10:15. As spray reagent 0.25 g of 4-Dimethlyaminocinnamaldehyd and 5 mL concentrated HCl in 25 mL methanol was used. After the development of the plate it was sprayed and heated up to 120 °C. Psilocybin yielded a violet spot at R_f = 0.47 whereas psilocin yielded a green spot at R_f = 0.71.

For instrumental TLC the system MeOH/H_2O 9:1 was used. In contrast to the procedure described above the plate was neither sprayed nor heated after development. Psilocin and psilocybin yielded spots under the UV light (254 nm) at R_f = 0.10 and R_f = 0.22 respectively. These spots were then detected with a Camag TLC Scanner II at 268 nm. Figure 5 shows the densitogram of the psilocin calibration curve. For the calibration curve (STD 1 - STD 4) 0.2, 0.4, 0.6 and 0.8 µg psilocin/µL was used. Psilocin could not be detected in the extracted mushrooms (S 1).

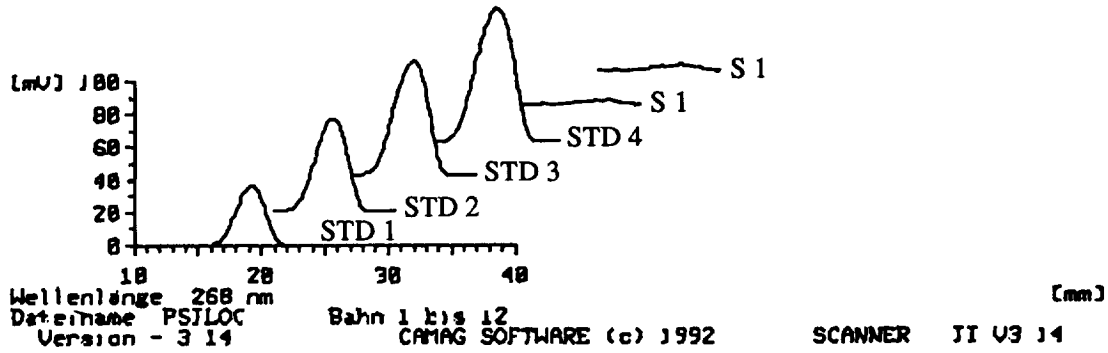

Fig. 5: Densitogram of the psilocin standard solution and extracted Psilocybe mushrooms

Figure 6 shows the densitogram of the psilocybin calibration curve (STD 1 - STD 4) and extracted Psilocybe mushrooms. For the calibration curve 0.5, 0.75, 1.0 and 1.25 µg psilocybin/µL was used. Psilocybin could be detected in the crude mushroom extract (S 1) as well as in its 1:10 dilution (D 1).

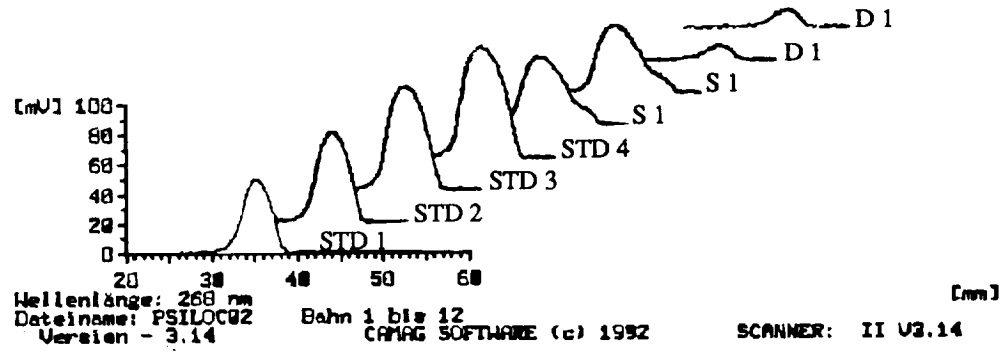

Fig. 6: Densitogram of the psilocybin standard solution and extracted Psilocybe mushrooms

Applications of IMS in forensic toxicology

A further application of IMS in forensic toxicology is the rapid detection of illicit or controlled substances (mostly heroine and cocaine) in biological samples like nose smears and fingernail dirt. The examination of fingernail dirt from people suspected to handle or deal with drugs is of great importance. Therefore our police officers are equipped with cotton swabs and requested to wipe the suspect's fingernails. For each hand one cotton swab moistened with methanol is used. Particles that cling to the cotton swab are either put directly onto the membrane filter or are eluted onto the filter with methanol. The solvent is evaporated in a gentle stream of air and the filter is then inserted into the Ionscan.

In forensic toxicology and forensic investigations quick answers for the route of intake of drugs into the body can also be obtained by IMS. In one case a person was found dead after a beer party. Since the medical examiners were unable to find the cause of death during the autopsy, nose smear was taken with the cotton swabs and also examined with IMS. The procedure of the examination was the same as described above. In both nostrils heroine could be found. With this quick analysis that was performed during the autopsy we were able to give indications for the direction of further investigations. Confirmation analysis done by GC/MS later, showed heroine, monoacetylmorphine and procaine present in the nose smear. Morphine could be found in the blood with a concentration of 0.7 mg/L. In addition the blood-alcohol concentration was 1.5 ‰. So the cause of death was determined as an intoxication with sniffed heroine in combination with ethanol [4].

CONCLUSIONS

We showed a number of interesting IMS applications in the daily casework of a forensic laboratory. IMS is a powerful tool to detect trace quantities of illicit or controlled substances on various surfaces and items of evidence. For most commonly encountered drugs (mostly heroine and cocaine) we observed excellent specificity and sensitivity. In the field of forensic toxicology the examination of fingernail dirt by IMS has proven extremely useful and successful. In a case of fatal heroine intoxication in combination with alcohol by examining the nose smear of the victim we could give indications for the direction of further police investigations. We also showed that the detection of psilocybin in Psilocybe mushrooms can rapidly be done by IMS without any sample preparation.

References

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